Semi-Annual Report
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A. Task Objective: Algorithm Development for Global Mapping of Phycoerythrin Pigment,Dissolved Organic Matter, and Chlorophyllous Pigment

1. MODIS North Atlantic Test Site Establishment and Characterization

As previously reported, the MODIS North Atlantic Test Site has been established as originally proposed. The Test Site includes the New York Bight/Mid-Atlantic Bight/Gulf Stream/Sargasso Sea and is conveniently located north and east of GSFC/WFF. Characterization has been initiated by ship sampling, aircraft overflights, and analysis of historical data available from within the NASA AOL project since 1980. Much of the data obtained in the northwestern portion of the test site will be used for algorithm development in Case 2 waters.

2. Selection of Case 1 Data Sets.

Airborne active-passive ocean color data acquired within Case 1 oceanic regions with the NASA Airborne Oceanographic Lidar is now being screened for use in algorithm development. Several promising candidate data sets have been identified.

B. Work Accomplished

1. In Situ Optical Characterization of the MODIS North Atlantic Test Site. As previously reported, the in situ characterization of the test site was initiated on February 28, 1991 with the acquisition of surface layer grab-samples during the Surface Wave Dynamics Experiment (SWADE). Through the cooperation of Dr. Charles Flagg arrangements were made to collect 20 samples along an in-bound track line from the Gulf Stream to the mouth of the Delaware Bay. The samples were filtered (0.45 um) to remove scatterers and absorbers other than the dissolved organic matter (DOM). Spectral absorbance of the filtered samples were acquired at Wallops, Cornell Laboratory for

Environmental Remote Sensing (CLEARS), and Woods Hole Oceanographic Institute. Spectral fluorescence of the filtered samples was also measured at CLEARS (Dr. Tony Vodacek, now a NRC Resident Research Associate at Wallops) and WHOI (Dr. Niel Blough).

Recovery of the absorption coefficients for the light-absorbing or chromophoric components of the dissolved organic matter (a CDOM) from their fluorescence emission has been investigated by laboratory analyses of the surface samples gathered from the Feb. 28, 1991 cruise. These absorbance and fluorescence analyses, (and work reported by others), suggest that absorption coefficients in the near ultraviolet can be directly retrieved from measurements of the fluorescence emission of CDOM. Thus, absorption coefficients in the visible can potentially be obtained from the empirical observation that CDOM absorption is exponentially related to wavelength. The errors in the laboratory fluorescence measurements were minimized through the combined use of the water Raman scatter as an internal radiometric standard and quinine sulfate as a reference. Thus, a CDOM algorithm retrieval errors are primarily attributable to the use of commercial spectrophotometers having maximum optical path lengths of 10 cm. Use of emerging technologies, such as the long-path reflecting tube absorption meter and the integrating cavity absorption meter, are suggested for future improvements to a CDOM retrieval algorithms. While the a CDOM retrieval appears feasible, the relationship to CDOM emission is susceptible to changes in fluorescence yield, so the continued temporal study of marine samples from many diverse oceanic locations is needed. When applied to shipboard and aircraft laser fluorometers, this retrieval methodology and the resulting DOM absorption coefficients will be used in ocean color models and associated satellite sensor/algorithm developments directly aimed at phycoerythrin retrieval. The DOM is important since it is a major interferant to the detection and quantification of chlorophyll and chlorophyll accessory pigments (CAP) such as phycoerythrin. Likewise, it is a contributor to the carbon cycle itself. A manuscript titled: "Inherent Optical Properties of the Ocean: Retrieval of the Absorption Coefficient of Chromophoric Dissolved Organic Matter from Fluorescence Measurements" is now is preparation based on the fluorescence/absorption work to date.

2. In-situ and Airborne Optical Characterization of

MODIS North Atlantic Test Site.

Through the cooperation of Dr. George Luther of the University of Delaware, 9 additional filtered and 9 unfiltered samples were gathered during a cruise of the Research Vessel Cape Henlopen on March 4, 1992. An overflight of the vessel was conducted on March 4, 1992. The purposes of this flight were to (1) calibrate the DOM fluorescence to water-Raman ratio [F(450)/R(401)] and to (2) provide a cross-shelf reconnaissance survey of the team member's MODIS North Atlantic Test Site during a periods not covered by historic AOL missions. The preliminary results indicated a surprising amount of phycoerythrin-bearing organisms already present in early March. Past flight historical experience has shown that the phycoerythrin-containing phytoplankton tend to have maximum numbers during late March to early April. The ship samples will be used to complement the previous samples and data base to improve the accuracy of the resulting algorithm(s).

3. Participated with the Airborne Oceanographic Lidar in Dr. Kendall Carder's TAMBEX II cruise of the Suncoaster in the Gulf of Mexico during the week of May 11, 1992. (Note that Dr. Carder is both a MODIS and a HIRIS Science Team Member). One of the prime objectives of this cruise was to obtain the necessary in situ ocean color data to address the CDOM algorithm development of Dr. Carder. Excellent airborne active-passive data were obtained for use in our own algorithm development as well. No significant phycoerythrin pigment fluorescence was observed with the AOL in the Gulf of Mexico, so no pigment extractions were attempted using the shipboard filtered samples.

D. Anticipated Activities During Next Half Year.

1. Phycoerythrin Algorithm Development Activities
Plans call for us to again directly address the quantification of the phycoerythrin signal as outlined in our own MODIS proposal. To assist us in this endeavor, we will again ask an established scientist such as Dr. Maria Vernet of the Scripps Institution of Oceanography to participate in experiments within the MODIS Test Site during spring bloom period of late March to early April. Additional (1) CDOM data and (2) first-time ship calibration of the airborne phycoerythrin-to-water Raman signal are the expected results of this field work.

2. Chlorophyll Pigment and CDOM Corrections to the Algorithm.

Major perturbations or influence to the ocean color spectrum are provided by chlorophyll and CDOM. These oceanic constituents significantly impede the retrieval of phycoerythrin pigment from the upwelled radiances. Accordingly, they must be dealt with in a systematic way in order to understand their effects and the impact on the retrieval of phycoerythrin and its ultimate quantification. In situ and airborne data gathered to date will be used to model the effects to ascertain the extent that they can be removed and/or quantified.

3. Additional flights of the NASA Airborne Oceanographic Lidar are planned for the MODIS Test Site during August, 1992 during preparation for the cooperative overflights in the Central Equatorial Pacific during NSF's Joint Global Ocean Flux Study of processes there. Of course, considerable Case 1 ocean color data will be obtained during the JGOFS flights along the -140W longitude from 5N to -3S and the several planned equator crossings in transit to Christmas Island for aircraft refueling. The equator crossings also provide data for the study of Tropical Instability Waves (TIW).

4. The lack of a 600nm band on MODIS-N is the biggest problem facing the retrieval of the phycoerythrin pigment on the first sensor launch. Plans to synthesize a 600nm band from existing bands will be performance tested using data obtained over actual oceanic phycoerythrin pigment using the 32-band AOL passive ocean color subsystem (POCS).